LUNAR RESUPPLY MISSION

SCIENCE AND TECHNOLOGY

MISSION DESCRIPTION

Lunar Gateway has been a success! Astronauts are beginning to live and work on the Moon for longer periods of time. They need supplies in order to carry out their scientific studies. You are tasked with building a lunar lander that can bring these supplies safely to the Moon's surface.

Using the materials provided and a raw egg, you and your team will design, budget, build, and test your lunar lander by dropping it from 1 metre, 2 metres, and 3 metres. Because you are conducting your preliminary testing on Earth, your team is permitted to use a parachute if your design calls for it. However, it is important to note that on the Moon there is very little atmosphere, so a parachute won't be as effective on the Moon as it is on Earth.

TIMELINE

Description	Duration
Background	15 minutes
Instructions	5 minutes
Group activity	90 minutes
Reflection questions	30 minutes
Wrap-up	10 minutes
Total	**2.5 hours**

Difficulty: **MODERATE**

Duration: **2.5 HOURS**

Material: **SUBSTANTIAL**

GOAL

Participants will build a lunar lander that will land safely on the Moon with its contents intact.

OBJECTIVES

By the end of this mission, participants will be able to

- Understand the importance of planning, designing and testing a safe lunar lander
- Create a design hypothesis and evaluate the success of their lunar lander and/or decisions they would make differently
- Understand the complexity of a lunar mission, including the challenges of a limited budget, and Canada's role in the future of deep-space exploration

BACKGROUND

The Canadian Space Agency (CSA) is working with national and international partners to write the next chapter of space exploration—sending humans to more distant destinations like the Moon (384,400 km from Earth) and Mars (225 **million** km from Earth). These daring missions will pose bigger challenges than travelling to the International Space Station (ISS), which is only 400 km from Earth. These challenges include longer communications delays, health risks for humans living without Earth's protective atmosphere, and missions that last longer than ever before.

These factors mean that crews and missions travelling farther from Earth will require more autonomy. The CSA is preparing for potential roles in these future missions by advancing technologies in areas of strength for Canada, like artificial intelligence, robotics and medical health care technologies.

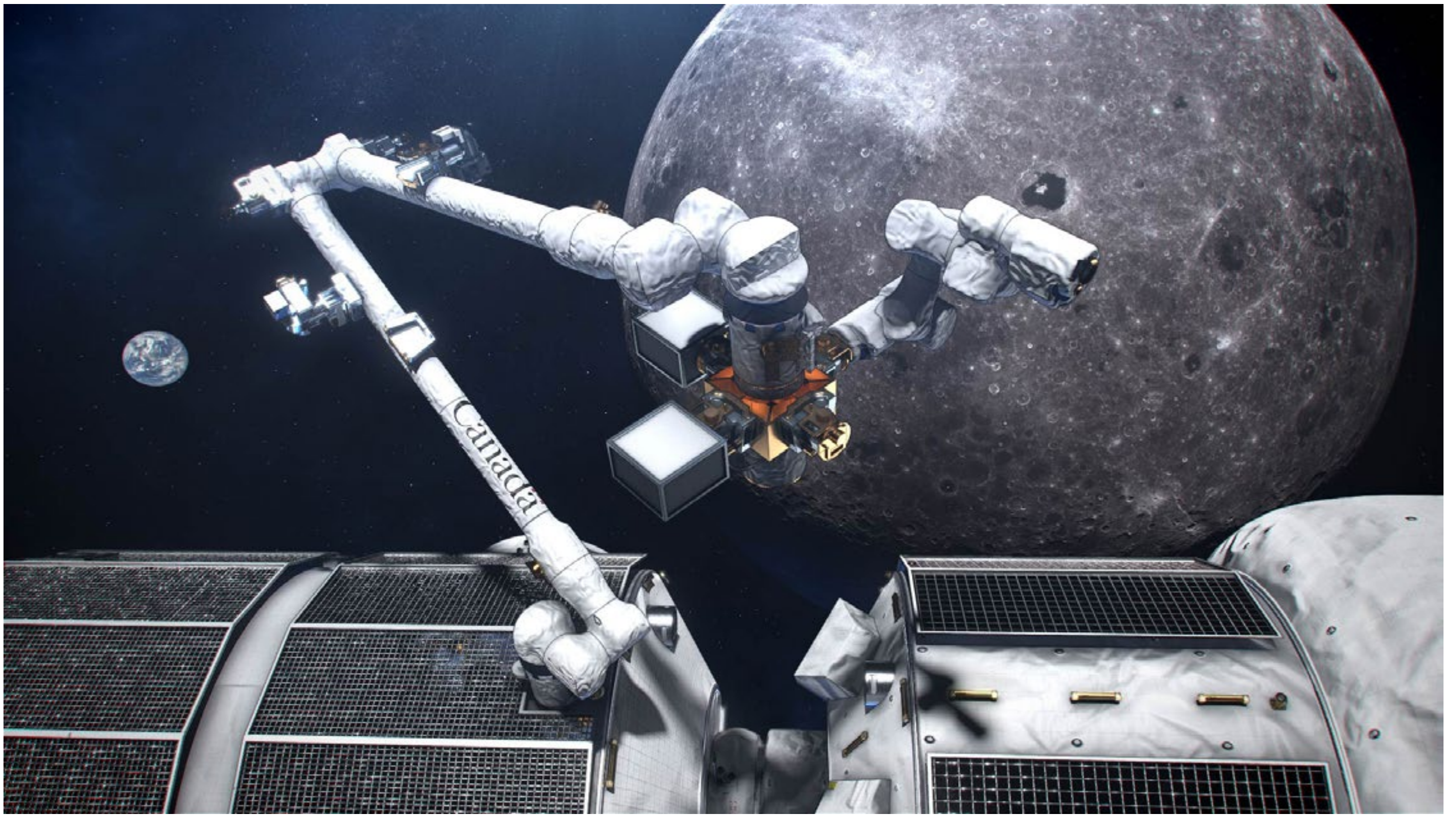
Landing on the Moon is a difficult task. In September 1959, USSR's Luna 2 became the first human-made object to successfully impact the Moon's surface. However, there were many missions before and after that were unsuccessful. Despite these difficulties, on July 20, 1969, Neil Armstrong and Buzz Aldrin became the first people to set foot on the lunar surface.

The CSA and their international partners are planning a return to the Moon with the Lunar Gateway, a small space station that orbits the Moon. Unlike the ISS, Gateway will not always be occupied by astronauts, so design, engineering, and testing are of the utmost importance. Using Gateway, NASA hopes to return to the Moon to conduct experiments and gain knowledge about our solar system.

You can find more information about Canada's role in the return to the Moon here:

Building on a lunar legacy: Canadian astronauts look towards a new chapter of Moon exploration:
http://www.asc-csa.gc.ca/eng/search/video/watch.asp?v=1_mx7pigjh&search=Gateway

Animation of Canadarm3, Canada's contribution to Lunar Gateway:
http://www.asc-csa.gc.ca/eng/search/video/results.asp?search=Gateway



Artist's concept of Canadarm3. Credit: Canadian Space Agency / NASA

MISSION PREPARATION

MATERIALS

- Various materials for constructing a lunar lander (at the discretion of the activity facilitator) may include:
  - Paper
  - Straws
  - Cotton balls
  - String
  - Tape
  - Popsicle sticks
  - Bubble wrap
  - Elastic bands
  - Fabric scraps
  - Paperclips
  - Pipe cleaners
  - Cardboard
  - Balloons
- Raw eggs (two per team – 1 for testing, 1 for the actual descent)
  Note: If eggs are not available, consider using soft modelling clay. Damage to the payload can be assessed by how many / how big the dents are in the clay.
- Scale (optional)
- Scissors
- Participant worksheet (one per team – see Appendix)

SET-UP AND PLANNING (FOR THE EDUCATOR)

- Select a safe place to drop eggs
- Set up a plastic sheet or garbage bag for the landing site (optional) – to catch the debris of a damaged lunar lander (i.e. cracked egg).
- Print enough worksheets (1 for each group).
- Assign a cost to each of the materials being used for building purposes (see proposed costs table in appendix).

MISSION INSTRUCTIONS

DESIGN CONSTRAINTS

1. The total cost of the materials used cannot be more than half the total cost of the materials given.
2. (Optional) The total mass of the lander cannot be more than half the total mass of the materials (not including the egg).
3. Approximately 25% of the egg must be showing.
4. (Optional) If multiple landers succeed in successfully delivering their payload, the one with the least mass wins.

THIS ACTIVITY WILL BE SPLIT UP INTO SIX SEPARATE PHASES

Design/Budget Phase

1. Use your creativity to design a lander that will keep your payload (egg) safe (i.e. not cracked) when dropped from 1, 2, and 3 metres.
2. Decide what materials you will use. Use the worksheet to keep track of budget and mass of the selected materials.
3. Remember! Your payload costs $300 000. Don't forget to add this into your budget total.

Construction Phase

1. Build your lunar lander according to your design.
2. Notice what works and what doesn't. What has to be changed from your original design? Record this information as well for the post-mission questionnaire.

Testing Phase

1. Time to test your design!
2. Did the test go as planned? Do you need to change anything from your original design?

Redesign Phase

1. If necessary, redesign or add materials to better protect your egg.
2. At the discretion of the activity facilitator – if teams must redesign or add materials to their lander, the price of the materials can increase by 10% to 20%.
3. If using eggs, it is at the discretion of the activity facilitator if materials that were used in first unsuccessful egg drop are replaced for free.

Launch Phase

1. Time to launch your lander – drop from 1 metre
2. If the egg is still intact, drop from 2 metres
3. If the egg is still intact, drop from 3 metres

Discussion Phase

1. Discuss how your lunar lander performed. Some questions to consider:
    - How successful was your design?
    - How different is the final product from your original design?
    - Was the project under/over/on budget?
    - If you were allowed a bigger budget (cost and mass), what would you have changed in your design?
    - Were you surprised by the results of the launch phase?
2. The activity facilitator can assign a winner of the activity based on each or all of these criteria:
    - Did the egg survive? (Was it cracked/broken?)
    - Was the project under/over/on budget?
    - Did the project take mass into consideration? (optional)

APPENDIX

PARTICIPANT HANDOUT

TEAM NAME: ______________________________

LUNAR LANDER NAME: ______________________________

1. The total cost of the materials used cannot be more than half the total cost of the materials given.
2. (Optional) The total mass of the lander cannot be more than half the total mass of the materials (not including the egg).
3. Approximately 25% of the egg must be showing.
4. (Optional) If multiple landers succeed in successfully delivering their payload the one with the least mass wins.

MATERIALS GIVEN

Participants are to fill in the total number of units of each of the materials given and calculate the total cost of all materials given.

Materials	Cost per unit (A)	Number of units given (B)	Cost of Materials (A x B)
Paper	$200 000		
Straws	$100 000		
Cotton balls	$100 000		
String	$50 000		
Tape	$300 000		
Popsicle sticks	$100 000		
Bubble wrap	$2 000 000		
Elastic bands	$50 000		
Fabric scraps	$1 000 000		
Paper clips	$25 000		
Pipe cleaners	$50 000		
Cardboard	$500 000		
Balloon	$2 000 000		
Total cost of all materials given:			

DESIGN

MATERIALS USED

Participants are to fill in the total number of units planned as per their design.

Participants then calculate the total cost of all planned materials.

Materials	Cost per unit (A)	Number of units per design (C)	Cost of Materials (A x C)
Paper	$200 000		
Straws	$100 000		
Cotton balls	$100 000		
String	$50 000		
Tape	$300 000		
Popsicle sticks	$100 000		
Bubble wrap	$2 000 000		
Elastic bands	$50 000		
Fabric scraps	$1 000 000		
Paper clips	$25 000		
Pipe cleaners	$50 000		
Cardboard	$500 000		
Balloon	$2 000 000		
Total cost of materials used:			

REFLECTION QUESTIONS

1. How did you decide what materials to use?

2. Did your team prioritize safety, budget, or weight? Why did you make this choice?

3. Did anything change from your original design? Why?

4. Did redesigning your lunar lander put you over budget?

5. Were you surprised by the results of the launch?

6. If you were to redo the activity, what changes would you make?

7. What would you do differently if there were no budget constraints?

8. What are three things you learned over the course of this activity?